A Standard Ordinance

for

CHIMNEY CONSTRUCTION

Suitable for Use in Cities
and Towns of Any Size
or as a State Law

Recommended by
The NATIONAL BOARD *of* FIRE UNDERWRITERS
COMMITTEE ON CONSTRUCTION OF BUILDINGS
Third Edition, Revised
1 9 2 7

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ISSUES OF THIS ORDINANCE

1st Edition 1920 30,000
2nd Edition 1921 55,000
2nd Edition 1921 Revised, 10,600
3rd Edition 1927, Revised and Enlarged, 50,000

FOREWORD

THE average annual fire loss due to defective chimneys and flues in the United States for the five year period of 1921-1925, as reported by the Actuarial Bureau to The National Board of Fire Underwriters, was $19,720,067. All losses are not reported, and it is conservatively estimated that the complete actual loss was 25 per cent. larger, thus making an approximate total loss per annum of $24,650,084. The number of lives sacrificed in the average 31,541 fires which produced this annual property loss is not definitely known, but is unquestionably large.

Since fires from this cause are classed as "strictly preventable," it should need no further argument to justify the promulgation of this Ordinance, which is suitable for adoption by a town of any size, or for enactment as a state law. The latter would be the more effective.

Conservation of our national resources is the demand of the hour. It is, therefore, the duty of all state and municipal authorities to use their best endeavors to stop this great, needless waste. A positive accomplishment in saving of life and conservation of property, as well as an increase in home comforts, would accrue from the enforcement of a law demanding safe chimneys of ample size and height to produce satisfactory draft.

Defective chimney fires would practically disappear if this Ordinance were generally enforced, and since the additional cost of the construction herein recommended as compared with uncontrolled practice would seldom exceed $25 to $50 per chimney, the requirement would not be burdensome. This increased expense would be returned many fold due to saving of life and property, and the efficient use of fuel.

Just prior to the printing of this third edition a broad and careful investigation of the performance record of lined chimneys throughout the United States was made. Although severe criticism had been directed at flue linings in general, the inquiry did not develop any serious conditions of failure and the foregoing statements are therefore reiterated. See Appendix I.

Abundant evidence showed that the defective flue linings found in service were nearly always the result of inferior workmanship. Exercise of reasonable care by masons will remove this serious source of trouble with only slightly increased cost, if any. Special attention is directed to the discussion of this subject as given in Appendix II and III.

The Actuarial Bureau statistics record the annual fire loss due to defective chimneys and flues as increasing rapidly. The approximate average yearly loss for the five-year period preceding 1921 was $15,493,946 and that for a five-year period ending in 1925 (the latest available figures) was $24,650,084. This shows an average increase of over 59 per cent. for a five-year interval, or 11.6 per cent. a year. For the year 1925 the loss was $27,092,316, including the 25 per cent. allowance.

During the same interval there were distributed through this office and other organizations approximately 150,000 copies of the earlier editions of this Ordinance strongly advocating proper chimney construction.

These facts indicate a discouraging indifference to the warnings which have been sounded and it is apparent for the general welfare of the country that legislation should demand public attention to this important subject.

The Ordinance has been reviewed and formally approved as here presented by the following organizations:

Clay Products Association,

Common Brick Manufacturers Association,

Eastern Clay Products Association,

National Fire Protection Association,

National Lime Association,

National Lumber Manufacturers Association.

The following organizations approved previous editions of the Ordinance and have reviewed this third edition. Unfortunately urgent demand for the Ordinance has necessitated a first printing before formal approval could be obtained.

American Institute of Architects,

American Society of Heating and Ventilating Engineers,

Heating and Piping Contractors National Association,

National Boiler and Radiator Manufacturers Association,

National Brick Manufacturers Association,

National Warm Air Heating and Ventilating Association.

Very helpful assistance in the preparation of the Ordinance and its revisions was rendered by various representatives of these organizations, also by individual experts: for all of which we express sincere appreciation. Especial recognition is extended to D. Knickerbacker Boyd, Consulting Architect of the Structural Service Bureau, Philadelphia, and to his office staff for valuable cooperation throughout the revision.

The foregoing broad approval of the requirements gives them a certification for correctness which has not hitherto been accorded to any similar set of specifications. It is, therefore, hoped the ordinance may be generally accepted as a construction standard in states and municipalities throughout the country. We urge its adoption.

The National Board of Fire Underwriters,
Committee on Construction of Buildings.

P. T. KELSEY, *Chairman,*

W. O. WAYMAN,	F. M. SMALLEY,
W. B. BURPEE,	H. M. SCHMITT,
PAUL B. SOMMERS,	C. W. JOHNSON,
F. C. WHITE,	F. E. JENKINS,
A. G. MARTIN,	J. D. LESTER,
E. J. BOOTH,	U. S. ATKINSON.

Correspondence in reference to the Ordinance should be addressed to

IRA H. WOOLSON, Consulting Engineer,
The National Board of Fire Underwriters,
85 John Street, New York City.

Should copies of the Plates used in the Ordinance be desired, they may be obtained at the cost of duplicating and shipping the electrotypes.

A STANDARD ORDINANCE

Providing Minimum Requirements for Proper and Safe Construction of Chimneys, Flues and Fireplaces in the

_____ of _____

Scope of the Ordinance.

This Ordinance does not apply to chimneys for high pressure boilers, furnaces used in manufacturing, or for other heating appliances where high temperatures are maintained; but shall apply to all ordinary chimneys which form a part of a building construction.

Section I. Chimney Construction.

1. The walls of all chimneys to which this Ordinance applies, whether the fuel used be coal, coke, wood, gas or oil, shall be built of brick, concrete, stone, hollow tile of clay or concrete, or of concrete block of such thickness, construction and flue lining as is hereafter specified, but this shall not preclude the use of a metal smokestack when located inside of a vent shaft having masonry walls not less than 8 inches thick and having an air space between the walls and stack on all sides, nor of metal stacks placed outside the building.

2. Flue linings shall be manufactured from fire clay or other suitable refractory clays, either natural or compounded, adapted to withstand reasonably high temperatures and flue gases, and shall have a softening point not lower than 1994 degrees Fahrenheit (Seger Cone 03). Flue linings shall be of standard commercial thickness but not less than 5/8-inch. They shall be carefully bedded one upon another in mortar, as specified in Par. 25, with all joints left smooth on the inside. See Appendix I.

The masonry shall not be built hollow and the lining dropped inside but shall be laid up with mortar, as specified in Par. 25, around each successive length of lining as it is set. All joints and spaces between the masonry and lining shall be thoroughly slushed and grouted full as each course of masonry is laid. No cracked, broken or otherwise defective linings shall be used. They shall start from a point not less than 8 inches below the center line of smoke pipe intakes, or in the case of fireplaces, from the apex of the smoke chamber (see elevation Plate I) and shall be continuous to the height required by Par. 13. No smokepipe intake shall be cut into a flue lining already set in place. See Appendix II and III.

3. Brick chimneys shall be built of good sound brick, or may be built of perforated radial brick manufactured for the purpose and

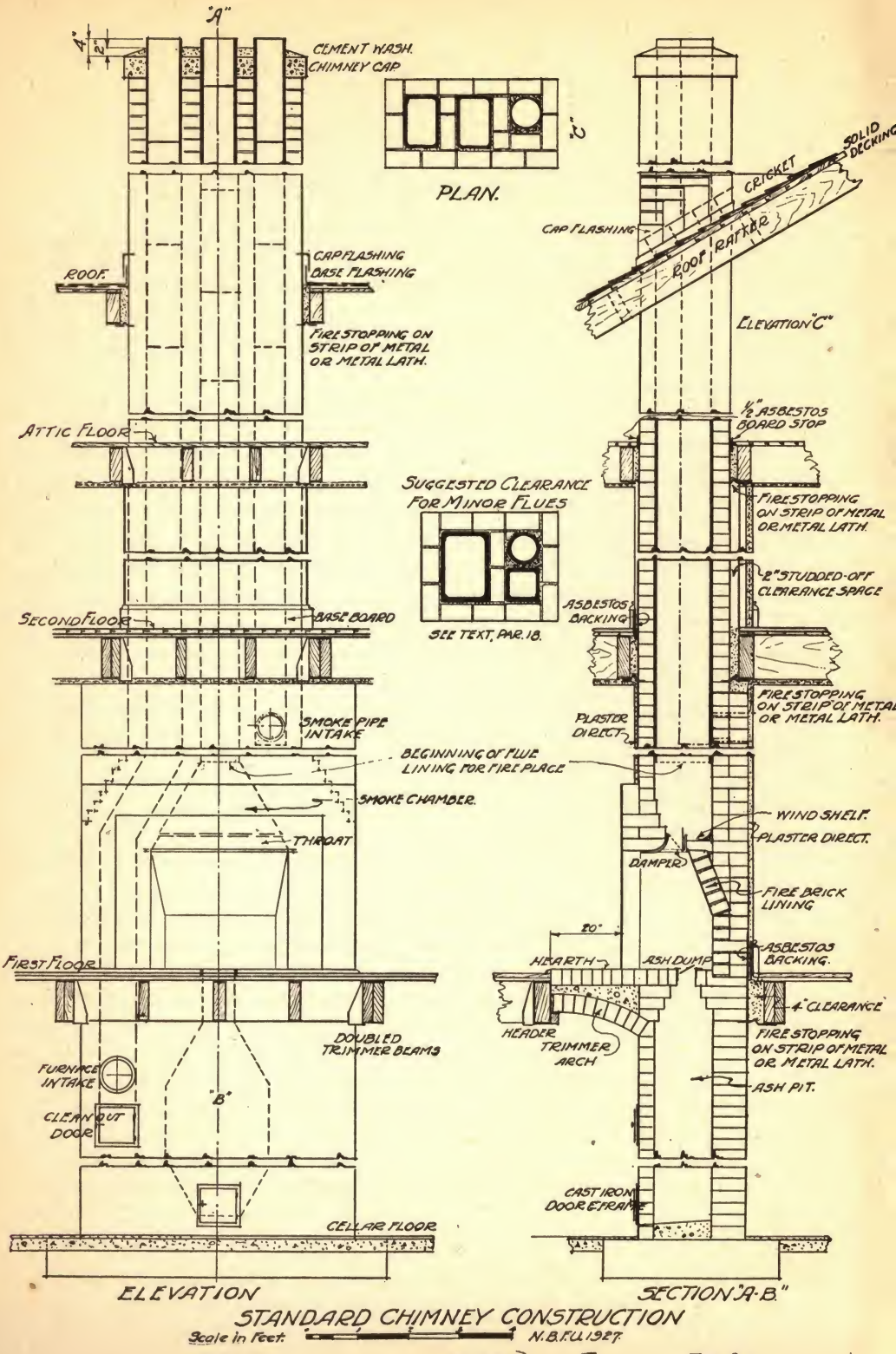


FIG. 1. PLATE I. FIG. 2.

Elevation and section of an recommended construction. Extra interior independent chimney showing flues can be added as desired.

adapted to withstand high temperatures, but no other hollow brick shall be used.

4. The walls of brick chimneys shall be not less than 3¾ inches thick (width of a standard brick), and shall be lined.

5. Flue lining may be omitted in brick chimneys for residence buildings provided the walls of the chimneys be not less than 8 inches thick, and the inner course be of fire brick or clay brick having a softening point not less than 1922 degrees Fahrenheit (Seger Cone 05). See Appendix IV and V.

6. Perforated radial brick chimneys may be unlined, provided the brick have a softening point not less than 1994 degrees Fahrenheit (Seger Cone 03), and be not less than 7½ inches in radial thickness, except that when such chimney is located inside a vent shaft having walls not less than 8 inches thick, the thickness of the chimney wall may be determined by engineering design. Such brick shall be shaped to the circular and radial lines of the various sections of the shaft so as to form uniform mortar joints.

7. All brick work shall be laid with full, push-filled, cross and bed mortar joints and shall be struck smooth where exposed to the weather. No mortar lining shall be permitted. See Appendix VI.

8. Concrete chimneys cast in place shall be suitably reinforced vertically and horizontally. The walls shall not be less than 3¾ inches thick and shall have flue lining.

Flue linings may be omitted in reinforced concrete chimneys for private dwellings provided the walls of such chimneys be not less than 6 inches thick, and provided further that quartz gravel be not used as the coarse aggregate. See Appendix VII.

9. Special chimney blocks or bricks shall have walls not less than 3¾ inches thick and shall be properly lined unless 8 inches in solid thickness. When more than one flue is provided in a single concrete block, it shall have suitable embedded reinforcement completely encircling the block and each of its flues shall be lined. See Appendix VII.

10. The walls of chimneys built of sawed or dressed stone in courses, properly bonded at corners and tied with metal anchors, shall be not less than 3¾ inches thick. Chimney walls of other stone shall be at least 4 inches thicker than required for sawed or dressed stone, but not less than 12 inches thick. All stone chimneys shall be properly bonded, or tied with non-corrodible metal anchors and shall have flue linings.

11. Masonry or concrete walls of buildings may form part of a chimney when the chimney walls are securely bonded into the walls of the building and when the flue is lined the same as an independent

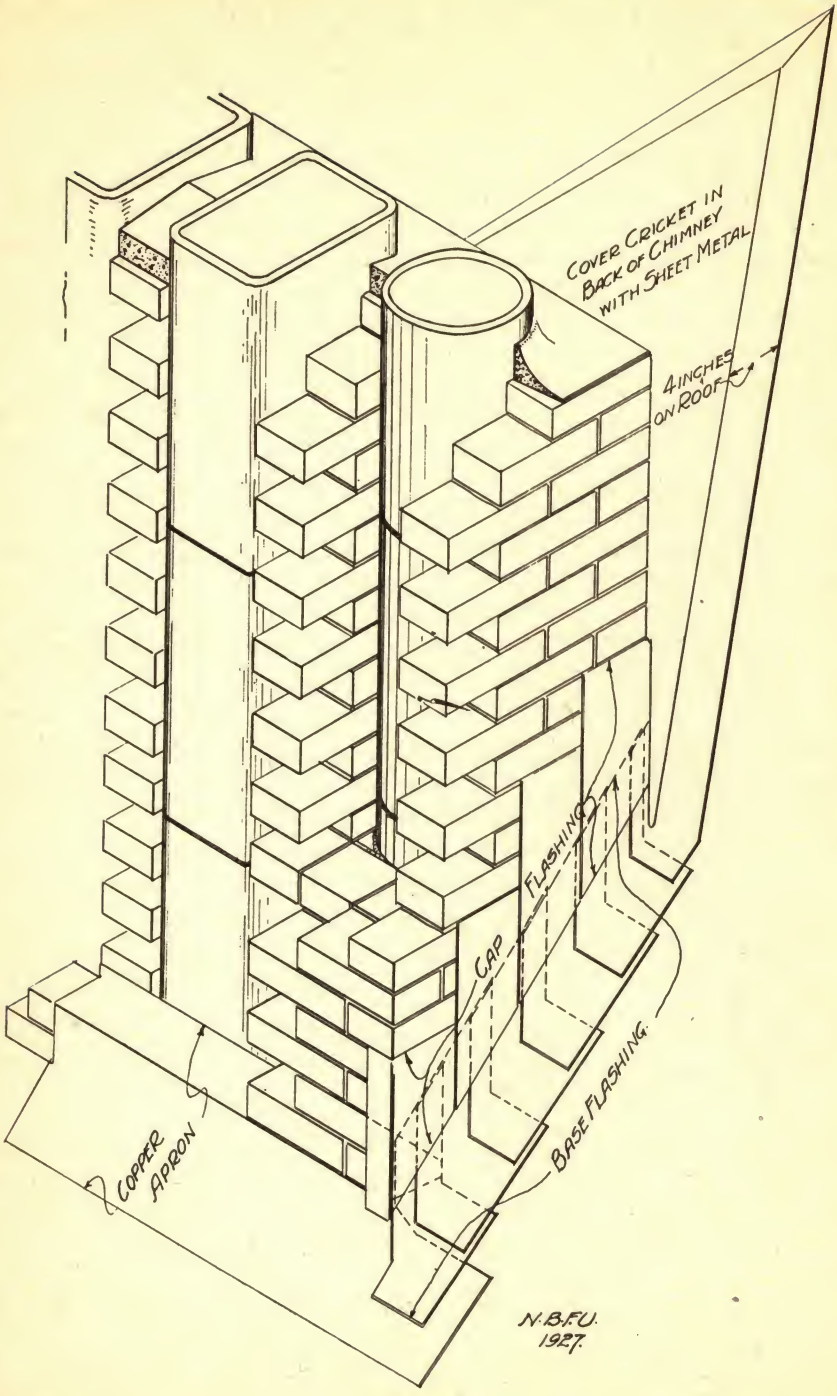


PLATE II.

Details of chimney construction showing method of flashing at roof surface, also a wash course, but no cap surrounding flues at top. See Plate I.

chimney. Flues in party walls shall not extend beyond the center of the walls and their location shall be permanently indicated on the opposite side of the wall. For mortar see Par. 25.

12. Hollow blocks or building tile of clay or concrete shall not be used for the walls of an independent chimney, but may be used for chimneys built in connection with exterior and party walls of hollow units for buildings not exceeding three stories in height. The outer 8 inches of such a wall may serve as the outside wall of the chimney, but the remainder of the chimney shall be constructed of two thicknesses of 4-inch block or tile set with staggered joints and having a total thickness of 8 inches; or may be built of 4 inches of solid masonry. All such chimneys shall be properly lined. See Plate V, Figs. 1 and 2, also Appendix VIII.

13. Chimneys shall be built at least three feet above flat roofs, and not less than 2 feet above the ridge of gable and hip roofs or the high point of mansards, irrespective of the distance of the chimney from such obstruction to draft. Unless provided with a stone, terra cotta, concrete, cast iron or other special cap or top, the chimney lining shall project not less than 4 inches. No type of chimney top shall decrease the required flue area. For mortar, see Par. 25. See Plates I and II, also Appendix IX.

14. Chimneys shall be built upon concrete or solid masonry foundations properly proportioned to carry the weight imposed without danger of settlement or cracking. The footing for an exterior chimney shall start below the frost line.

15. Chimneys in frame buildings shall always be built from the ground up, or rest on masonry basement or foundation walls. Chimneys shall not rest upon or be carried by wooden floors, beams or brackets. nor be hung or supported by metal stirrups from wooden construction.

16. The total offset, overhang or corbel of an independent chimney shall not exceed three-eighths the width of the chimney in the direction of the offset. See Appendix X.

Corbeled chimneys shall not be supported by hollow walls or walls of hollow units. Solid walls supporting corbeled chimneys shall be not less than 12 inches thick, and corbeling shall not project more than one inch per course and not more than 6 inches in any case.

17. Flues shall be built as nearly vertical as possible but in no case at an angle greater than 45 degrees from the vertical. Where flues change direction, the abutting linings at the angle joints shall be cut to fit closely, and at no point shall the cross section area be reduced. See Appendix X.

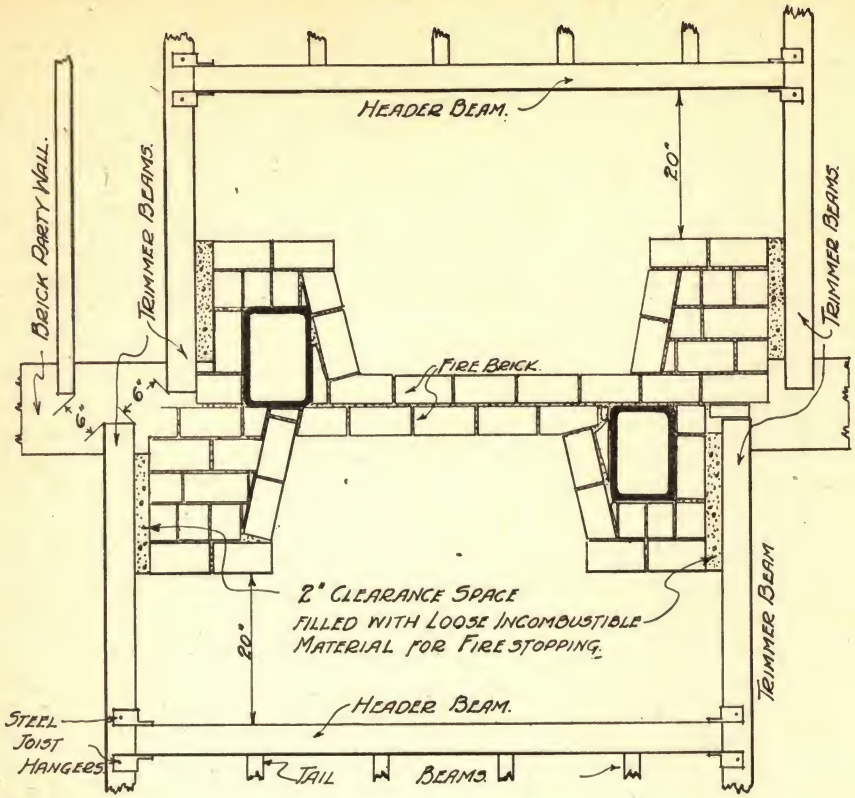


FIG. 1

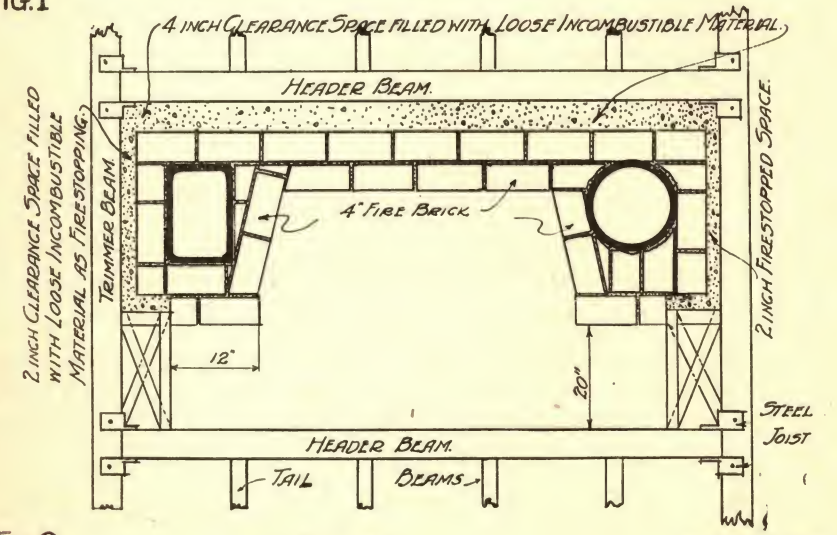


FIG. 2

Fig. 1.—Method for building two fireplaces back-to-back in a brick party wall to secure proper spacing between ends of floor joists.

Fig. 2.—Floor framing around a single fireplace. Note filling between framing and brickwork, which serves both as insulator and fire-stop.

18. Not more than two lined flues shall be permitted in the same flue space, and the joints of any such adjoining flue linings shall be staggered at least 7 inches. When there are more than two flues in a chimney, at least each third flue shall be separated from the others by a smoke-tight withe or division wall of masonry or concrete not less than 3¾ inches thick and bonded into the chimney walls. Each flue intended for a heating furnace or boiler connection, or for a fireplace, shall be separated from other flues by such a withe. See Plate I and Appendix XI.

19. When any single flue has an effective area exceeding 200 square inches, the walls shall be not less than 8 inches thick and shall have flue lining as previously specified, but when flues become so large as to render it impracticable to obtain fire clay flue lining, such flues shall be lined with fire brick for a distance of at least 25 feet from the point of intake. For mortar see Par. 25.

20. Connections between chimney and roof shall be made with sheet metal cap and base flashing (copper recommended) arranged to allow for any vertical or lateral movement between chimney and roof. See Plates I and II.

21. No increase of chimney wall thickness, nor any projecting masonry, or set back, shall be permitted within a distance of 6 inches above or below the rafters or roof joists.

22. Fireplace walls shall be not less than 8 inches thick, and if built of stone or hollow units, not less than 12 inches thick. The faces of all such minimum thickness walls exposed to fire shall be lined with firebrick, soapstone, cast iron or other suitably fire resistive material. When lined with 4 inches of firebrick, such lining may be included in the required minimum thickness, as indicated in Plate III. For mortar see Par. 25. See Appendix XII.

23. There shall be but one connection to a flue irrespective of whether the fuel used be coal, coke, wood or oil.

Ordinary and low pressure heating devices burning solid fuels shall have a minimum effective* flue area not less than the following:

Small special stoves and heaters	28 sq. inches
Stoves, ranges and room heaters	40 sq. inches
Fireplaces (at least 1/12 the fireplace opening)	50 sq. inches
Warm air furnaces, steam and hot water boilers	70 sq. inches

The construction and size of flues to be used for oil and gas fired furnaces, boilers and automatic water heaters, shall be the same as required for corresponding appliances burning solid fuel.

*NOTE: The effective area of a flue is assumed to be that portion of its internal area actually producing draft. For theory and discussion of effective area see Appendix XIV. The cross section of an oblong flue should have a short dimension not less than two-thirds the length.

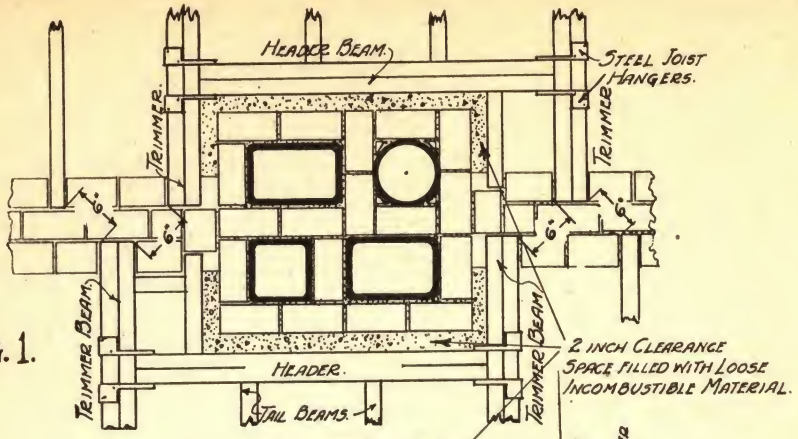


FIG. 1.

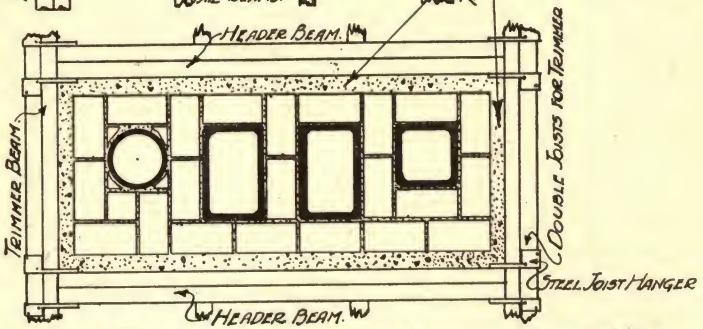


FIG. 2.

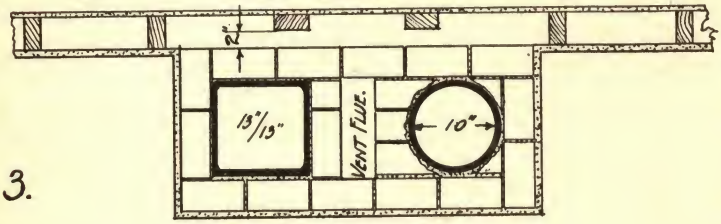


FIG. 3.

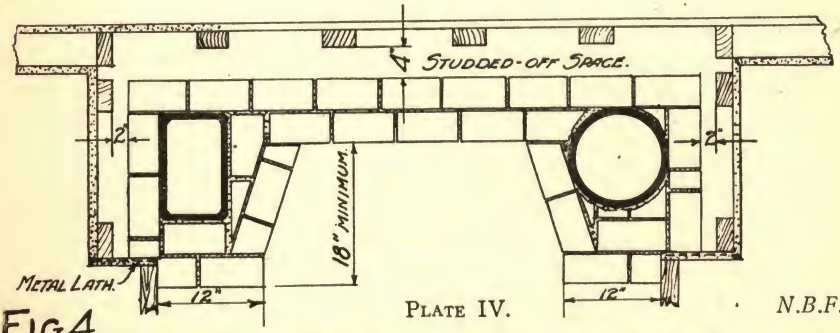


FIG. 4.

PLATE IV. N.B.F.U. 1927.

Fig. 1.—Floor framing around chimney in a party wall, to secure proper spacing between ends of floor joists.

Fig. 2.—Ordinary floor framing around a chimney. All timbers 2 inches clear of brickwork and space filled with fireproofing material.

Fig. 3.—Stud partition across back of a chimney showing proper method of arranging studs.

Fig. 4.—Stud partition across back of a fireplace and around the ends of the chimney breast, showing proper arrangement of studs. Method of fire-stopping this space is shown on chimney section, Plate I, also in Fig. 2, Plate III.

Vent flues for non-automatic water heaters, stoves, ranges and other domestic gas appliances having relatively small gas consumption (excepting gas plates and portable gas heating appliances) shall have a flue area of not less than 10 square inches. Such flues unless enclosed in solid masonry walls, shall be of incombustible material not less than three-fourths of an inch thick with air tight joints and shall vent through and above the roof.

24. Smokepipes shall enter the side of chimneys through a fire clay or metal thimble or flue-ring of masonry. The top of smokepipe intakes shall be set not less than 18 inches below sheet metal ceilings, wood lath and plaster or exposed wooden joists. Neither the intake pipe nor thimble shall project into the flue. No woodwork shall be placed within 6 inches of the thimble. When a smokepipe enters a chimney breast through a studded-off combustible partition, the thimble shall be kept 6 inches clear of all woodwork and be surrounded by metal lath and plaster.

25. Mortar used between the joints of flue linings and in the portions of a chimney above a roof or otherwise wholly exposed to the weather shall be mixed in proportion of one part portland cement to not more than three parts of clean sand.

Fire brick used for the lining of flues or facing the interior of fireplaces shall be laid in fireclay mortar.

All mortar used in chimney construction, except as specified above, shall be not leaner than the following mix by volume: one part portland cement, one and one-quarter parts hydrated lime, six parts clean sand, thoroughly mixed to a uniform color before wetting. In lieu of hydrated lime, slaked putty lime may be dissolved in the mixing water. See Appendix XV.

26. After a chimney has been completed, all flues, intakes and cleanouts shall be thoroughly cleaned and left smooth on the inside.

27. All flues to which large ranges, heating furnaces, boilers, automatic gas water heaters or fireplaces are to be connected shall be subjected to a smoke test before acceptance, but the test shall not be made until the mortar has thoroughly seasoned. The method of test is to build a smudge fire at the bottom of the flue and while the smoke is flowing freely from the flue, close it tightly at the top. Escape of smoke into other flues or through the chimney walls indicates openings that shall be made tight before the chimney is accepted. The test shall be made by the mason contractor in the presence of the Building Inspector or other official having jurisdiction, and of the owner or his representative.

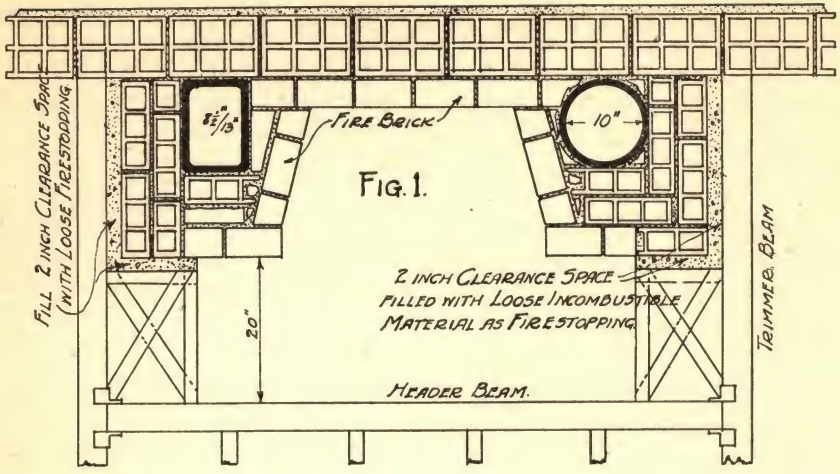


FIG. 1.

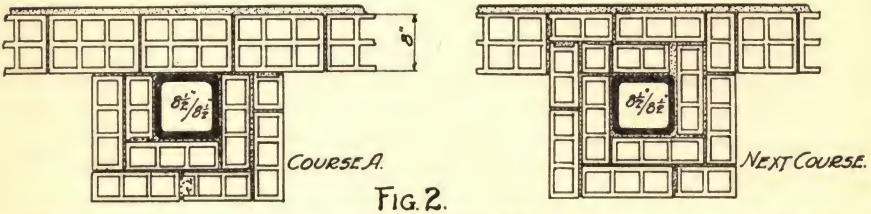


FIG. 2.

APPROVED HOLLOW TILE CONSTRUCTION FOR FIREPLACE AND CHIMNEY.

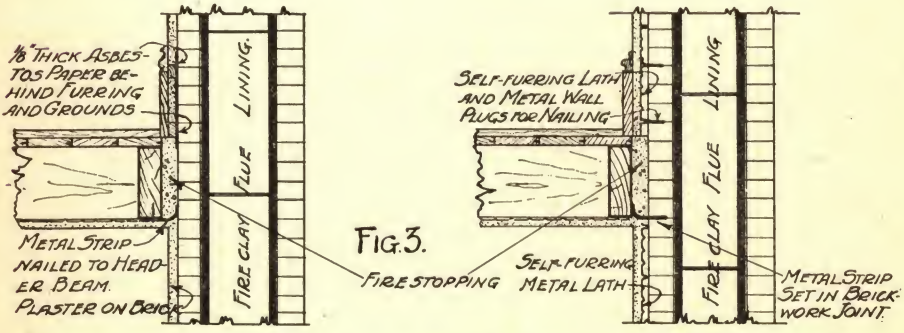


FIG. 3.

APPROVED WOODWORK PROTECTION. N.B.F.U. 1927.

PLATE V.

Section II. Woodwork Around Chimneys.

1. No wooden beams, joists, rafters or studs shall be placed within 2 inches of chimney walls, whether the same be for smoke, air or other purpose. No woodwork shall be placed within 4 inches of the back wall of any fireplace. See Plate III, Fig. 2, and Plate IV, Fig. 4.

2. All spaces between chimneys and all tiers of wooden joists or beams shall be filled with loose crushed cinders or mortar refuse, gypsum block or other porous incombustible material to form a firestop. See Plates I, III, IV and V.

The incombustible material shall be supported by strips of sheet metal or metal lath set into the brickwork or nailed to the wooden beams, forming a buckled flexible joint close to the inner edge of the chimney, as indicated in Plates I, Fig. 2 and V, Fig. 3, or other approved methods using incombustible material.

3. No wooden studding, furring, lathing, plaster grounds or plugging shall be placed directly on any chimney or in its joints. Wooden construction shall either be studded off from the chimney, or the plastering shall be directly on the masonry, or on metal lathing, or on incombustible furring material. Wood placed around chimneys to support base or other trim shall be insulated from the masonry by asbestos paper, at least ⅛ inch thick, and metal wall plugs or approved incombustible nail holding devices in the joints shall be used for nailing. See Plate V, Fig. 3. See Appendix XVI (a).

4. All fireplaces and chimney breasts shall have trimmer arches or other approved fire-resistive construction supporting hearths. The arches and hearths shall be not less than 20 inches wide measured from the face of the chimney breast, and not less than 12 inches wider than the fireplace opening on either side. The arches shall be of brick, stone or hollow tile, not less than 4 inches thick. A flat stone or a reinforced concrete slab may be used to carry the hearth instead of an arch if it be properly supported and a suitable fill be provided between it and the hearth. Hearths shall be of brick, stone, tile or concrete as may be specified. Wood centering under a trimmer arch shall be removed after the masonry has thoroughly set.

5. No heater burning solid fuel shall be placed in a fireplace which does not conform to the foregoing requirements. No such device shall be connected to a gas vent flue. When a mantel is employed it shall be of incombustible material.

6. No wooden mantel or other woodwork shall be placed within 8 inches of the jambs or within 12 inches of the top or arch of any fireplace opening. No combustible summer piece or fire-board shall be used.

7. Any person or persons, whether owner, builder or mechanic, who shall build a chimney or flue in violation of any requirement of this Ordinance shall be deemed guilty of a misdemeanor and shall be fined not less than $25 nor more than $..... for each offence: and any chimney or flue which is built in violation of any requirement of this Ordinance shall be immediately demolished or rebuilt. It shall be the duty of the Building Inspector or other duly authorized official to enforce this Ordinance.

8. All ordinances or parts of ordinances in conflict with this Ordinance are hereby repealed.

9. This Ordinance shall take effect upon being approved by the .....

APPENDIX

This Appendix contains reasons for certain requirements in the Ordinance and various suggestions for good practice not suitable to be included in the Ordinance itself but which are thought to be useful information to accompany it. The material is, therefore, appended for its educational value, and a municipality in adopting the Ordinance can dispose of the Appendix as it sees fit.

I. Fire Clay Flue Linings.

It should be noted that no change is made in the quality and specification requirement for flue linings as given in the first edition, 1920, of this Ordinance.

During the preparation of this third edition severe criticism was received upon the behavior of flue linings under severe conditions. This criticism, the first received in the many years the National Board of Fire Underwriters have advocated their use and which principally emanated from three sources, was so drastic and so contrary to previous conception of the value of flue linings that it demanded thorough investigation.

Over 250 copies of a letter of inquiry were addressed to the best obtainable list of persons in all parts of the country who would be likely to have experience with the subject. The principal object of the inquiry was to ascertain if badly cracked, broken or disintegrated flue lining was a condition commonly found existing in chimneys long in service. If so, it was desired to ascertain whether the conditions found were influenced by shape of the lining, quality of clays employed, degree of burning, methods of manufacture, or the quality of workmanship in chimney construction.

The investigation, conducted in a careful, unbiased manner, did not reveal serious criticism of flue lining itself. Of the large number of replies received, less than 10 per cent indicated any trouble in the serviceability of lined chimneys, and three-quarters of this portion were directly traceable to sub-standard practices or the use of cracked or otherwise unsuitable flue linings. Such defects reported were attributable more to methods of installation violating the provisions of Section I, Par. 2 or to poor workmanship (discussed in Appendix II) than to the use of inferior quality flue lining. The broad approval registered, supported the general belief that good quality flue linings properly installed are a reliable material and a necessary part of all thin-walled chimneys. See also Appendix III.

II. Workmanship.

a. Among the responses to the inquiry discussed in the preceding article came a number of criticisms concerning workmanship and defective trade practice in preparing smoke pipe and cleanout openings. It is a fact that such intakes cannot be successfully cut into flue linings already surrounded by masonry. Examination shows that when such openings are cut after the flue is completed, the section of lining pierced is likely to be badly shattered and fall out of place, thereby blocking the flue. The highest flue temperatures occur at this point, which, if without lining, presents a serious fire hazard and usually impedes draft.

b. In order to avoid the foregoing bad practice, the mason should procure a "starting" flue with a scribed or "knockout" side opening (prepared by the lining manufacturer) or he should cut and prepare the proper size of intake and thimble before placing the lining in the chimney.

c. Cutting of flue lining is best done by placing an empty bag in the lining, filling the bag with damp sand and tamping it to fit the lining tightly. The length, standing on end, can then be cut with a chisel and light hammer. With a reasonable degree of care, proper intake connections, mitres or angles can thus be made without shattering the lining.

d. In an effort to solve the difficulty of cutting intake openings into round linings, some lining manufacturers propose to provide special round "starting" sections with a T branch of sufficient length to serve as a smoke pipe thimble. The branch will be situated 8 inches from one and 16 inches from the other end of the section, thereby allowing ample latitude for variations in height of smoke pipe intake.

III. Bricklaying.

A common method of building up chimney walls hollow for many courses and then dropping a section of lining into the hollow space has proven to be very bad practice. Inspection of defective chimneys shows this method of construction to be a cause for leaky and hazardous flues having unsatisfactory draft. The method of building flue linings and chimney walls as specified in Par. 2, of Section 1, is essential to good draft and fire safety and should be appreciated by competent masons who take pride in their craftsmanship.

IV. Heat Resistance of Brick.

a. Brick meeting the temperature requirement of Section 1, Paragraph 5, of the Ordinance can be obtained in all markets at a cost slightly above that of ordinary brick. In several regions the ordinary brick will meet the requirement, and involve no additional cost.

b. It is suggested that each manufacturer of flue linings or heat resisting brick suitable for chimney and fireplace lining should have tests made of the softening point of their products. Such tests should be made by a laboratory of recognized standing, and the test certificate would constitute the authority for acceptance of the product as fulfilling the requirements, provided suitable identification marks were placed on the material. This would be a simple method of accomplishing the object, and the quality of clay from any particular bank is usually sufficiently uniform to secure reliable results.

V. Thickness of Exterior Chimney Walls.

For exterior chimneys, or chimneys having any wall exposed to the weather, it is recommended that all such exposed walls be not less than 8 inches thick even though lined. This additional thickness will produce a more uniform temperature in the flue, thereby improving the draft, which will result in fuel economy and a lessening of probability of smoke annoyance.

VI. Mortar Lining.

It has been common practice in constructing unlined brick chimneys to plaster parging mortar upon the inner walls of the flue as the masonry progresses. The fallacy of such substitution for flue lining is evident by examining old flues so constructed. The combined effect of wind, expansion and contraction due to temperature changes, and flue gases, causes disintegration of such lining. Safe and sound construction prohibit the continuance of this custom.

VII. Concrete in Chimney Construction.

Pure quartz gravel or other highly silicious gravel concretes are not adapted to withstand high temperatures, therefore should not be used where subject to direct attack of heat. The reinforcement required in concrete chimneys cast as a unit, or when built of large blocks enclosing more than one flue, is to resist stresses due to temperature variations or to unequal settlement of foundations.

VIII. Filling of Hollow Building Tile.

When chimney walls are built of hollow units as provided in Section 1, paragraph 12, it is recommended that the inner course of cells next to the flue lining be filled with mortar.

IX. Chimney Top.

When the top of the masonry is not provided with a cap or when a flat cap is used, the lining should protrude four inches in order to permit the use of a two-inch thick rich portland cement wash or splay. This not only tends to prevent down draft but also sheds water from the masonry. See Plates I and II.

X. Offsets in Flues.

It is important that flues be constructed as nearly vertical as possible since each offset retards draft and offers a lodging place for the

accumulation of soot, thereby reducing the efficiency and increasing the fire hazard. When the direction of a flue must change, it should preferably not depart more than thirty degrees from the vertical. The ends of linings forming offset joints should be carefully cut, fitted and set. When such joints are improperly made, the flue area may be reduced to such a degree as to destroy an otherwise excellent draft. See Appendix II (c) for practical method of cutting.

XI. Withes.

A withe between at least every second and third flue in a chimney is strictly necessary to insure stability of the chimney. A withe also aids in securing uniform temperature in a flue and prevents air leakage, thus promoting good draft and fuel economy. At the same time it prevents possibility of a fire in one flue communicating to the others. For these reasons every flue connected with a fireplace or heating furnace of any type is required to be separated from other flues by such withes. The ideal chimney would have all flues separated by withes. See Plate IV.

XII. Fireplace Walls.

For unusually large fireplaces the wall thickness required shall be correspondingly increased to support the greater loads imposed and to afford additional fire protection for the more severe temperatures expected.

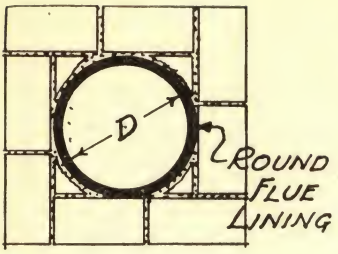
XIII. Effect of Chimney Dimensions and Altitude Upon Draft.

To secure adequate draft under all conditions of wind and humidity, the area and height of a chimney should be directly proportional to the size and character of heating appliance attached to it. The choice of too small a flue is sure to result in poor draft, inefficiency of heating equipment, continued annoyance and, possibly, involve expensive alterations. In altitudes exceeding 4,000 feet above sea level, where rarified atmospheres may require increased area or height of chimney flues, or both, chimney experts should be consulted. Authorities on the subject claim losses of 13 to 20 per cent. in draft intensity at that altitude.

XIV. Theory of Draft Efficiency and Effective Area.

(a) The following discussion of draft efficiency, influenced by size and shape of flue and character of flue surface, and the tabulation in Part B of Table II, page 23, are developed from an analysis of the subject presented in a Code of Minimum Requirements for the Heating and Ventilation of Buildings, recently issued in tentative form by the American Society of Heating and Ventilating Engineers. Based upon a prevailing conception of draft in ascending a flue, the discussion of net effective areas for lined and unlined round, square and oblong flues is amplified and the formulae for their determination are graphically derived. For comparative values of effective area for all types and sizes of flues, see Table I, page 22.

(b)

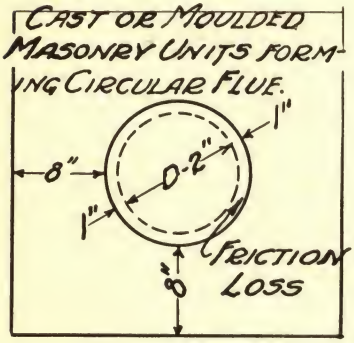


Case I.

From the foregoing assumption the accompanying sketch shows the net area of the dependable draft column to be the area of the greatest circle that can be inscribed within the round flue lining indicated. Calling D the internal diameter of the lining, we have for its effective area

$$*E_1 = \frac{\pi D^2}{4}$$

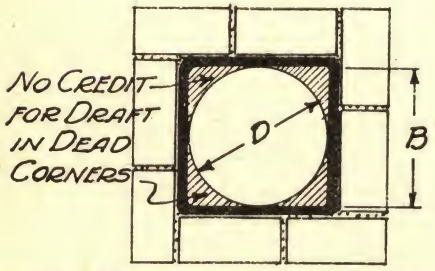
*NOTE: This draft or effective area in square inches "E" is defined in the note Sec. I, Par. 23.



Case II.

For an unlined chimney having a circular flue it is claimed that the layer of air within one inch of the masonry is practically inactive due to friction between the masonry and the draft column and that this amount should be deducted in determining the dependable effective area. Deducting two inches from the diameter of such a round flue, we have, from the formula of Case I

$$E_2 = \frac{\pi (D-2")^2}{4}$$

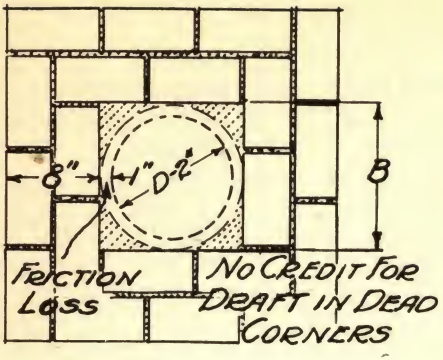


Case III.

For a square flue having a smooth surface its effective flue area is claimed to be the same as that of a smooth round flue of equal internal diameter. See Case I. If this assumption is correct, the four cross-hatched corners in the accompanying sketch are inactive as far as draft is concerned and their total area represents 21.5 per cent. of the total internal area B^2. The effective flue area is represented by the circle having D for diameter and tangent to all four walls of the flue, viz.:

$$E = \frac{\pi D^2}{4}$$

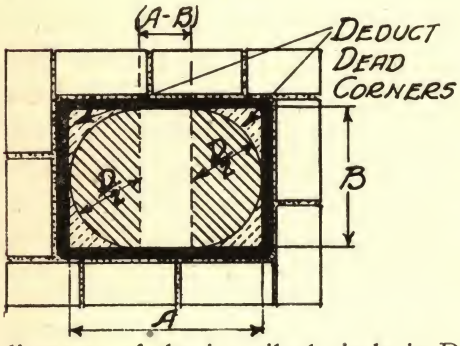
Since D = B, $E_3 = \frac{\pi B^2}{4}$



Case IV.

In the case of an unlined square brick flue with an area B^2, the maximum inscribed circle has an area equal to $\frac{\pi D^2}{4}$. While this deducts the area of the inactive corners, friction of the draft column upon the frequently jointed masonry at the points of tangency and upon the inactive air or accumulated soot in the corners necessitates further deduction to obtain the dependable effective flue area,

viz.: $$E_4 = \frac{\pi (D-2'')^2}{4} = \frac{\pi (B-2'')^2}{4}$$



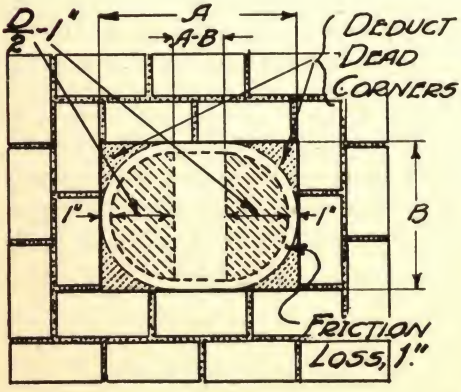
Case V.

The oblong flue lining shown is a common type in which the breadth B is approximately two-thirds the length A. Applying the principle of Case III, it is seen that the effective area is the summation of the area of the half circle inscribed tangent to each end, plus the area of the rectangle between them. The diameter of the inscribed circle is D, which is the same as breadth B.

The area of the circle is $\frac{\pi D^2}{4} = \frac{\pi B^2}{4}$

The area of the rectangle is $(A-D) \times B = (A-B)\ B$

The effective area is, then $E_5 = \frac{\pi B^2}{4} + (A-B)\ B$



Case VI.

In an unlined oblong flue, the same conditions obtain as in Case V with respect to the deduction for the dead corners, with the additional deduction for friction loss due to the rough flue walls. Applying the deduction of 2 inches to the formula

$E_5 = \frac{\pi B^2}{4} + (A-B)\ B$, we have

$$E_6 = \frac{\pi (B-2'')^2}{4} + (A-B)\ (B-2'')$$

(b) The foregoing discussion would appear to substantiate the claim that a round flue lining will provide a better draft than other shapes having equal cross-sectional area and operating under the same conditions. It is therefore recommended that round rather than rectangular flues be employed wherever practicable. However, when round linings are used, care must be exercised to insure complete filling of the corner spaces with brick and mortar, otherwise there is likely to be air leakage into such vacant spaces, a condition which is liable to injure the draft and increase the fire hazard.

(c) Attention has been called in the preceding paragraph to the alleged advantages of round flue lining over other shapes with respect to draft. In localities where soft coal is used it has been found that the dead corners of rectangular flues accumulate soot, which if not removed by periodic flue cleaning is likely to cause chimney fires and may damage the chimney. Circular flue linings keep reasonably clean, even when soft coal is employed, and an additional advantage accrues to their use in minimizing the hazard of chimney fires. Square and rectangular linings, more commonly used because of the ease with which they can be built in, give equally satisfactory results if chosen on the basis of effective draft areas suggested in the tables on pages 22 and 23.

(d) In designing a fireplace and determining the proper size of flue, a few points essential to adequate draft should be considered. Except where coal grates are used, the height of fireplace opening from hearth to the underside of arch should approximate three-fourths the clear width. It has been customary to use a flue with an internal area one-tenth or one-twelfth the area of the fireplace opening. The variable ratio of effective flue area to actual flue area for different shapes of flues has been responsible in many cases for the unsatisfactory results from application of this rule. By reducing all flue areas tc effective draft area, this variation in efficiency is eliminated. It is, therefore, recommended that such linings as have an effective flue area at least one-twelfth the area of fireplace opening be selected. Attention is also called to the importance of a wind-shelf or smoke-shelf. (See Section A B Plate I.) This is essential to reduce the tendency toward puffy action induced by gusty wind and down-draft, especially in chimneys which do not exceed approximately thirty-five feet in height.

TABLE I.

Data on Flues, Areas and Chimneys With and Without Flue Linings.

NOMINAL SIZES		Unlined chimneys. Inside dimensions	Actual inside area sq. in.	Effective area "E" sq. in.	Minimum thickness of chimney wall
Round flue lining. Inside diameter	Rectangular flue lining. Outside dimensions				
.....	.....	4"x8"	32	11.1	3¼"
.....	.....	4"x12"	48	19.1	3¼"
.....	4½"x8½"	.....	23.6	21.3	3¼"
6"	.....	.....	28.3	28.3	3¼"
.....	.....	8"x8"	64	28.3	8"
.....	7½"x7½"	.....	39.1	30.7	3¼"
.....	4½"x13"	.....	38.2	35.9	3¼"
.....	8½"x8½"	.....	52.6	41.3	3¼"
8"	.....	.....	50.3	50.3	3¼"
.....	.....	8"x12"	96	52.3	8"
.....	8½"x13"	.....	80.5	70	3¼"
10"	.....	.....	78.5	78.5	3¼"
.....	.....	12"x12"	144	78.5	8"
.....	8½"x17½"	.....	106	96.5	3¼"
.....	13"x13"	.....	127	100	3¼"
12"	.....	.....	113	113	3¼"
.....	.....	12"x16"	192	126	8"
.....	13"x17½"	.....	177	150	3¼"
15"	.....	.....	177	177	3¼"
.....	17½"x17½"	.....	233	183	3¼"
.....	20"x20"	.....	298	234	8"
18"	.....	.....	254	254	8"
.....	20"x24"	.....	357	295	8"
20"	.....	.....	314	314	8"
.....	24"x24"	.....	461	346	8"
22"	.....	.....	380	380	8"
24"	.....	.....	452	452	8"

(e) Part B, of the following table is an adaptation of similar data appearing in the revised tentative "Code of Minimum Requirements for the Heating and Ventilation of Buildings." It resulted from investigations by the American Society of Heating and Ventilating Engineers and the Structural Service Bureau. A comprehensive laboratory research is contemplated by that Society in an endeavor to standardize boiler ratings and obtain more accurate data upon chimney sizes. This will possibly require two or more years to complete, and in the meantime Part B of Table II presents the best information upon the subject now available. It should be noted that the capacities are not listed manufacturers' ratings but are guaranteed performance determined by uniform rating specifications.

TABLE II.

Minimum Vent, Flue and Chimney Sizes, with and without Flue Linings.

(A) GAS APPLIANCES, STOVES, RANGES and FIREPLACES.

USE	Types of Flues (Minimum)			Effective flue area required "E" sq. inches	Thickness of flue lining	Outside dimensions of lined chimney
	Round lining. Inside dimensions	Rectangular lining. Outside dimensions	Unlined flue. Inside dimensions			
Gas Vents, small capacity.....	6"	4½"x8½"	**4"x8"**	11.1	.....	12"x16"
Gas Vents, multiple.....	8"	**7½"x7½"**	8"x12"	30.7	⅝"	16"x16"
Gas Vents, large capacity.....	8"	**4½"x13"**	8"x12"	35.9	⅝"	12"x21"
Small stoves, special.....	6"	7½"x7½"	**8"x8"**	28.3	⅝"	15"x15"
Stoves and ranges.....	8"	**8½"x8½"**	8"x12"	41.3	⅝"	16"x16"
Fire places	8"	8½"x13"	8"x12"	50.3	¾"	18"x18"

(B) FURNACES AND HEATING SYSTEMS.

Capacity			Types of Flues (Minimum)			Effective flue area required. "E"	Thickness of flue lining	*Outside dimens. of lined chimney
Warm Air sq. inches leader pipe	Radiation		Round lining. Inside dimens.	Rectangular lining. Outside dimens.	Unlined flue. Inside dimens.			
	Steam sq. feet	Hot Water sq. feet						
790	590	973	10"	**8½"x13"**	12"x12"	70	¾"	**17"x21"**
1000	690	1140	**10"**	13"x13"	12"x12"	78.5	⅞"	**20"x20"**
	900	1490	12"	**13"x13"**	12"x16"	100	⅞"	**21"x21"**
	1100	1820	**12"**	13"x17½"	12"x16"	113	1"	**21"x26"**
	1700	2800	15"	**13"x17½"**	16"x20"	150	⅞"	21"x26"
	1940	3200	**15"**	17½"x17½"	16"x20"	177	1⅛"	25"x25"
	2130	3520		**17½"x17½"**	16"x20"	183	⅞"	**26"x26"**
	2480	4090	18"	**20"x20"**	20"x20"	234	1⅛"	23"x23"
	3150	5200	**18"**	20"x24"	**20"x20"**	254	1¼"	33"x33"
	4300	7100	**20"**	24"x24"	20"x24"	314	1⅜"	39"x39"
	5000	8250		**24"x24"**	24"x24"	346	1½"	40"x40"

NOTE: The sizes shown in **bold type** produce the exact minimum effective areas "E" and with the chimney wall thicknesses indicated in the last column of Table I, page 22, require a chimney of the approximate size shown in the last column above. The other minimum types indicated as equivalents will actually furnish areas slightly in excess of the minimum. See Table I, page 22.

*When an unlined chimney is used (except for gas vents), the wall thickness must be 8 inches, which necessarily increases the outside dimensions beyond the size given for lined chimneys in the last column.

The foregoing sizes are ample for flues of ordinary height such as found in one to three story dwellings, small mercantile and similar buildings. Where flues are less than 35 feet above heating appliance, sizes in excess of those indicated by the table are recommended. Flues larger than 12 inches in diameter are usually found in taller buildings whereby the necessary height is automatically provided.

(f) A similar table and chart of flue sizes and chimney heights just released by a special technical committee of the National Boiler and Radiator Manufacturers Association is based upon total volume of a building in cubic feet and its maximum heating requirement in B. T. U.'s. These apply to a much broader range of flue sizes and heating capacities than is contemplated for the application of this ordinance.

The method is derived from scientific data and the values indicated by its use may be quite as accurate as claimed by its advocates. However, there is as yet no experience concerning its correctness or practicability. Its fundamental principles are so different from those commonly employed that it seemed best not to include it in the ordinance as an alternative method for determining chimney sizes lest it prove more confusing than helpful.

Faulty operation of flues serving heating systems is largely attributable to a lack of uniform methods for calculating chimney sizes. It is hoped that the research work referred to in Par. (e) will incorporate the best principles of all methods into a generally recognized practical standard.

A recommendation thus substantiated will be welcome for inclusion in this ordinance and would be considered sufficient excuse for a new edition.

XV. Chimney Mortar.

Although an accurately measured mortar mix is always desirable, a good practical method, approximating the specification of Par. 25, is the following: 4 full shovels (No. 2 flat) portland cement, 5 shovels hydrated lime, 1 wheel barrow (3 cu. ft.) damp sand: all thoroughly turned and mixed with sufficient clean water for proper consistency.

XVI. Suggestions for Repair of Unlined Chimneys.

(a) A chimney that becomes too hot to hold the hand against comfortably is dangerous if there is woodwork touching it. Have it carefully inspected by a reliable mason, and apply the protection prescribed by this Ordinance as far as possible.

(b) The smoke test specified in Section I, Par. 27, is strongly recommended as the best method for discovering defects which indicate danger. If smoke escapes at any place, the chimney should be repointed or rebuilt as conditions may warrant.

(c) Where soft coal is used it is often necessary to rebuild unlined chimney tops every few years, and all unlined chimneys, irrespective of fuel used, are liable to become defective through disintegration of the mortar joints. In order to ascertain if chimneys need rebuilding, climb to the top and look inside. If mortar has begun to fall out from between the bricks it will soon do so all the way through the wall. With an ice pick, a table knife, or other sharp implement, try to push through the mortar; if you can do so, rebuild at once as follows:

Tear the chimney down to a point where mortar joints are solid, but at least 18 inches below the roof, get fire clay flue linings approximately the same size as the inside measurement of the chimney, set them in the flue and build up with good brick and Portland cement mortar. This will make a solid chimney through the roof where there is greatest danger, and is the best that can be done unless the chimney is completely torn down and rebuilt. Preserve a clear space of at least 1 inch between the woodwork of the roof and the chimney wall, and connect the chimney with the roof by metal flashings. Build to a height above the roof as specified in Section I, Paragraph 13, of the Ordinance.

XVII. Cleaning Chimney Flues.

(a) For efficient and safe operation of heating apparatus it is extremely important that both the chimney flue and the smoke passages in the heating device be free from soot. When bituminous coal is used, soot accumulates rapidly and frequent cleanings are necessary. Soot in a chimney introduces the risk of a chimney fire with the consequent danger of sparks being thrown upon the roof or penetrating cracks in the chimney walls. For this reason chimneys should never be purposely burned out to clean them. Furthermore, the burning out of a flue is liable to crack the lining or damage the chimney.

(b) A common and efficient method of cleaning a chimney is to sweep it with a properly weighted bundle of rags or a bush attached to a rope and worked from the top; there are also various efficient patented chimney cleaning devices. However, the operation is troublesome and therefore cleaning is too often neglected. A layer of tarry soot $\frac{1}{16}$ inch thick on boiler tubes or in furnace passages will decrease their heating efficiency 20 per cent., hence the necessity for keeping them clean as well as the chimney.

(c) In previous editions of this publication the use of salt, scrap zinc and zinc compounds were recommended for removing soot from flues and furnace passages. It was stated that these materials, thrown on a hot furnace fire, produced fumes which disintegrated the soot. These methods were advocated by supposedly good authority, but recently the reliability of chemical cleaning has been questioned. Thus far no dependable authority has been found willing to vouch for the accuracy of the claims then made. In any event, it is certain that no

such agencies are as effective as good mechanical flue cleaning devices and their use should be discouraged, except in emergencies.

XVIII. Extinguishing Chimney Fires.

(a) A handful or two of powdered sulphur thrown into a furnace fire is claimed to be effective in extinguishing a soot fire in a chimney. Burning sulphur reduces the oxygen in the air supply, forming sulphur dioxide in quantity (2⅛ times heavier than air), which produces a smothering effect upon the flue fire.

(b) A few pounds of salt thrown down the flue is an old and excellent remedy for a soot fire. Even a pail of sand, earth or ashes is helpful. Such materials, however, should be used with much care, if at all, in a fireplace chimney flue, for they are likely to scatter burning soot into the room where the fireplace is located.

XIX. Importance of Gas Venting.

The supreme importance of providing vent flues for small gas-burning appliances is emphasized every year by numerous fatalities resulting from defective installation, faulty operation or accident. It is urged that all gas appliances be installed in strict accordance with the National Gas Safety Code.